Extremely Durable and Low-Cost Concrete: Ultralow Binder Content and Ultrahigh Tensile Ductility

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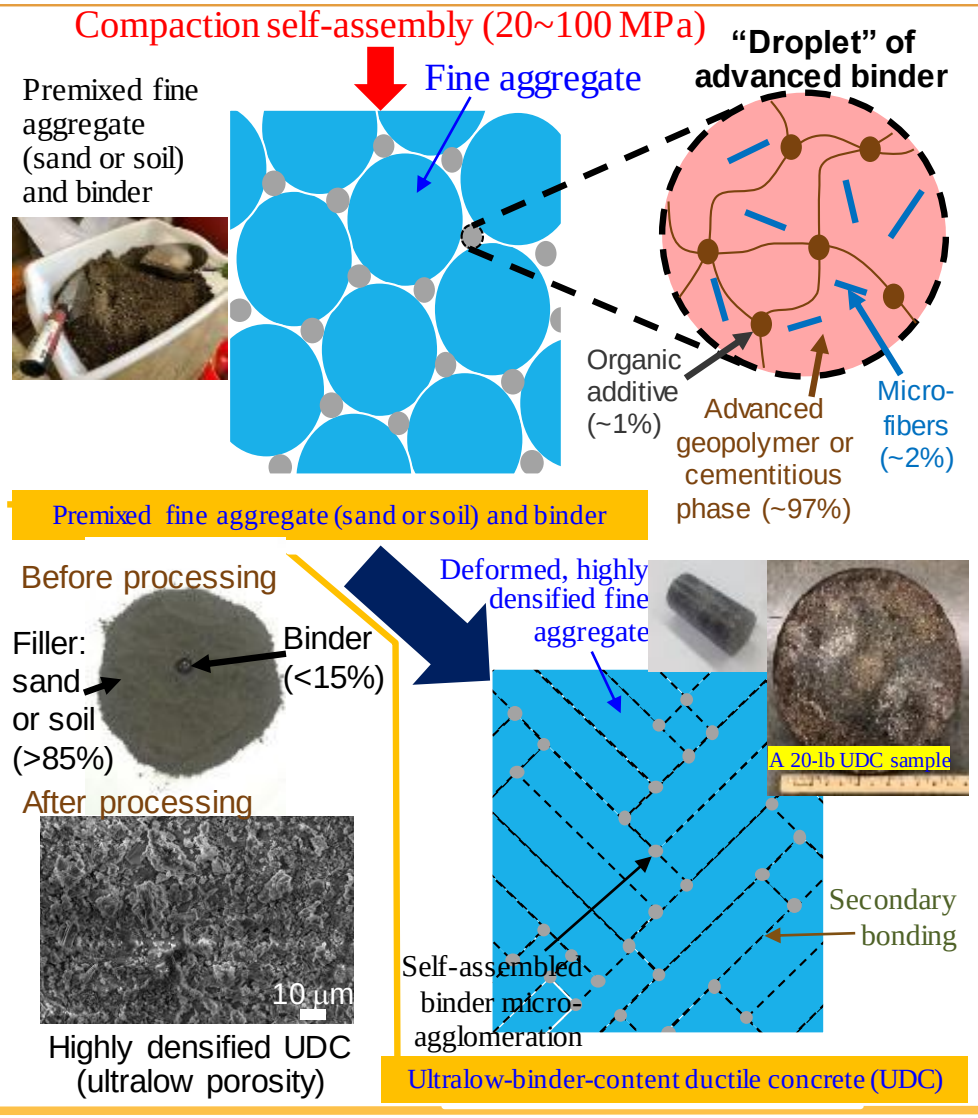
Project Vision

- Using advanced binder to drastically improve the concrete durability
- Using compaction to largely reduce the binder content (much reduced cost, enhanced strength and ductility, reduced carbon emission, etc.)

Total Project Cost:	$1.3M
Length	24 mo.

The Concept



- 1~3% microfibers drastically improve the concrete durability
- Compaction (30~100 MPa) greatly reduces the binder content to only 10~15%, to
  - ➢ Reduce the cost (~OPC)
  - ➢ Further improve the ductility and strength
  - ➢ Reduce carbon emission
  - ➢ Reduce the use of class-F fly ash (if geopolym binder)

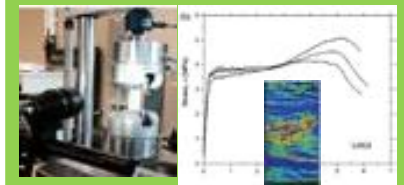
The Team

Research & Development

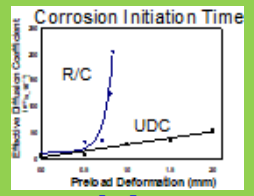
Prototyping & Commercialization

Co-PI Li, AsAssociate Professor at UCI: expertise in chemistry and micro-structure of cementitious materials and geopolymers

Binder chemistry and strength design



Tailoring for tensile ductility



Durability Validation

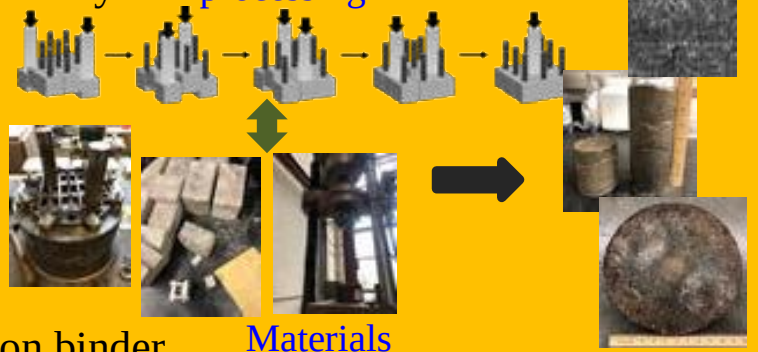
Binder strength, ductility, permeability

Requirements on binder viscosity, tackiness, etc.

Advanced binder development

PI Qiao, Professor at UCSD: inventor of CSA; expert of processing of infrastructural materials

Optimization of processing



Materials characterization

Prototypes

UDC Production

Business Partner, TBD

TEA

MKT/industry knowledge

IP

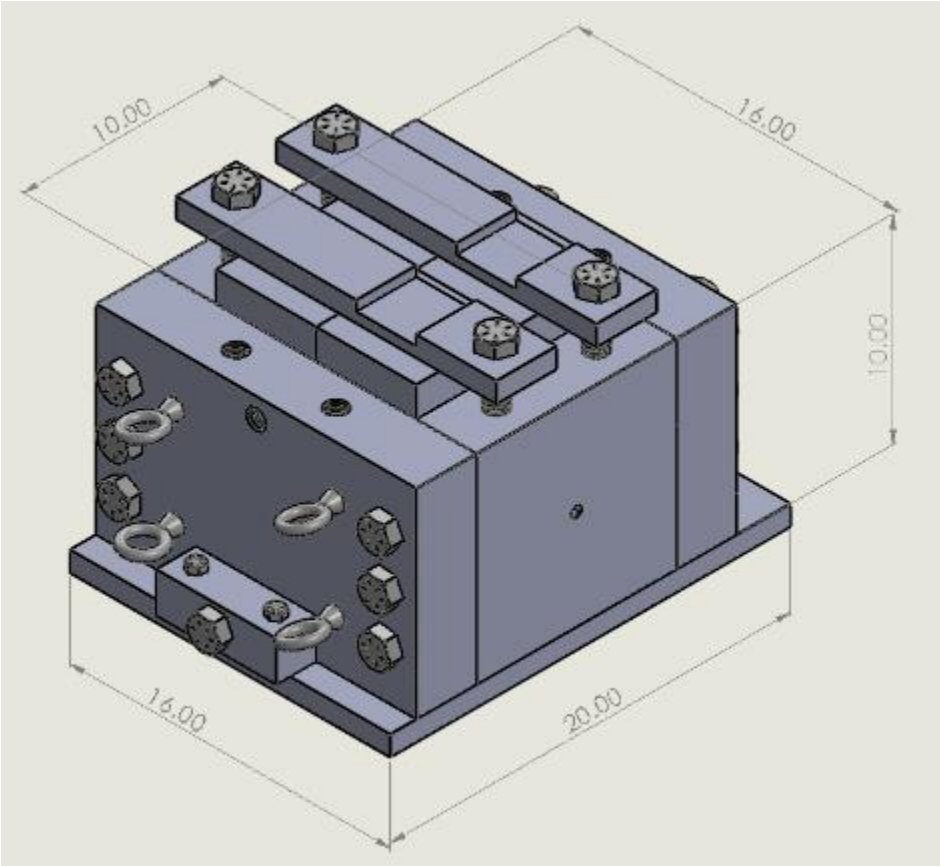
T2M paln

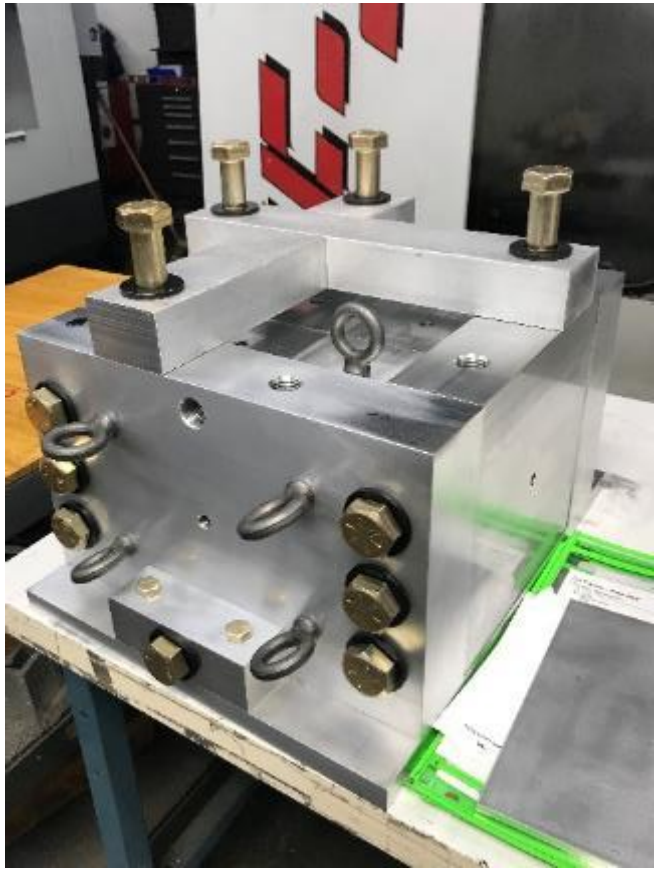
Commercialization

Project Objectives

- Q4: Proof of concept: compaction formation (UCSD)
  - Low binder content (10~15%, compared to ~25% in regular concrete)
  - Adequate strength (>5,000 psi)
- Q4: Advanced binders (UCI)
  - Ductility at least 10X
- Q8: Production of 500-lb demonstration units (UCSD, UCI)
- T2M (seeking partners/collaborators):
  - Market niche: precast parts (1/7 of the total construction materials market)
  - Licensing vs. start up

Results (I)

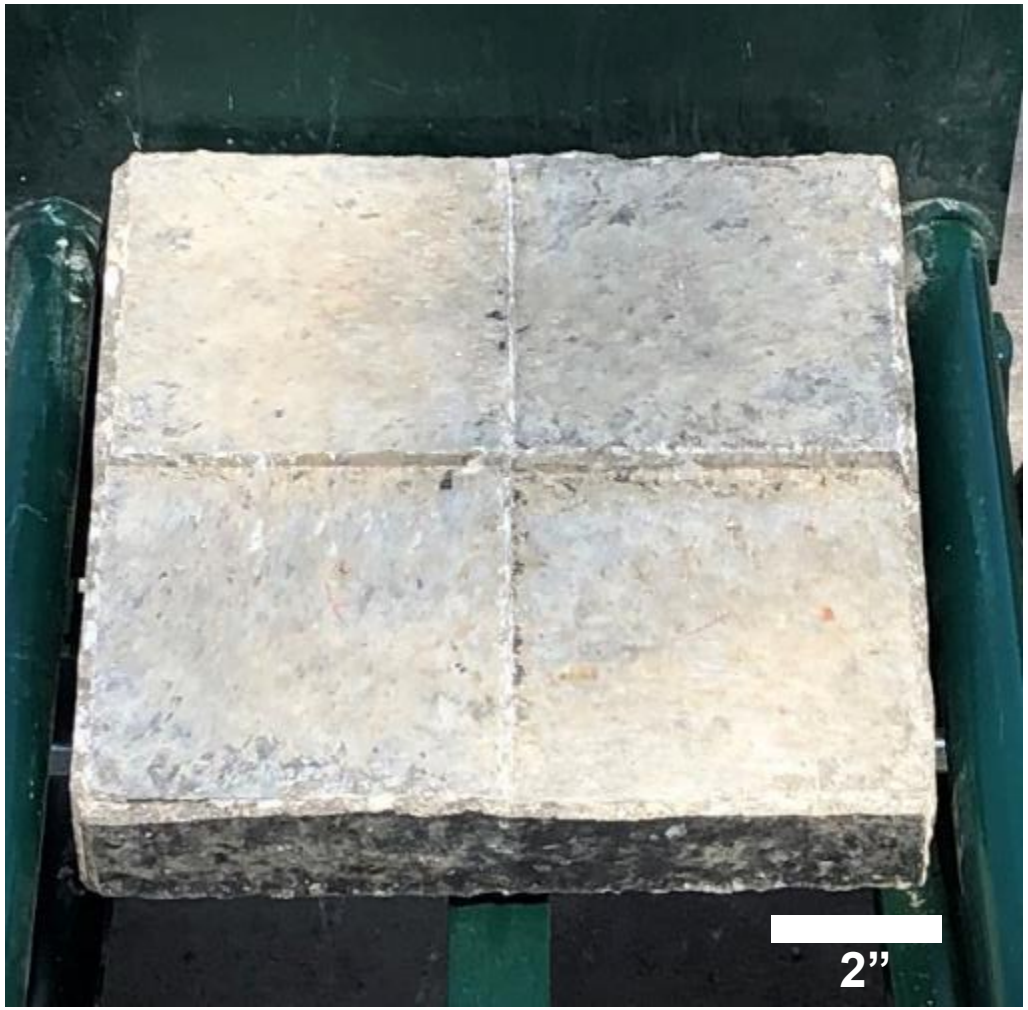


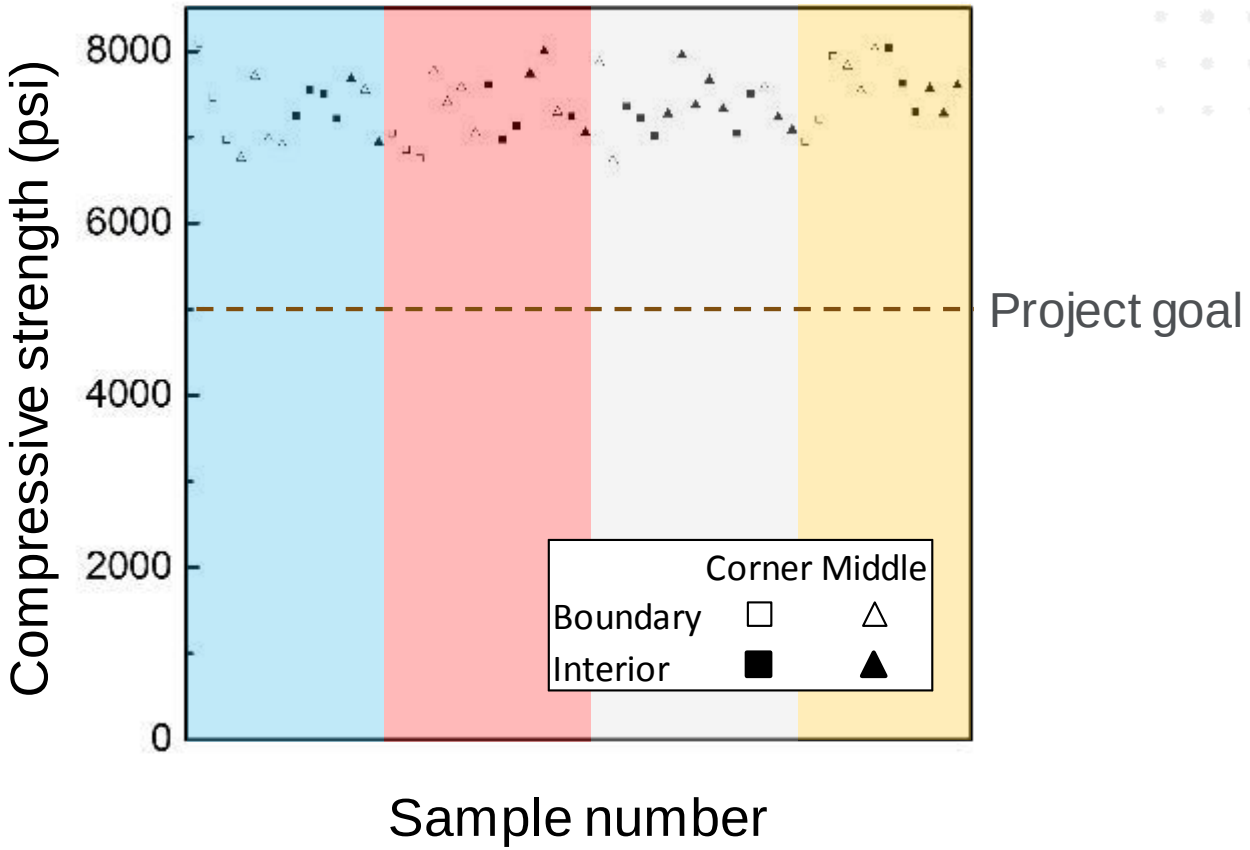


- An aluminum box was developed
- Compaction was performed section by section, by using a regular press

Results (I)

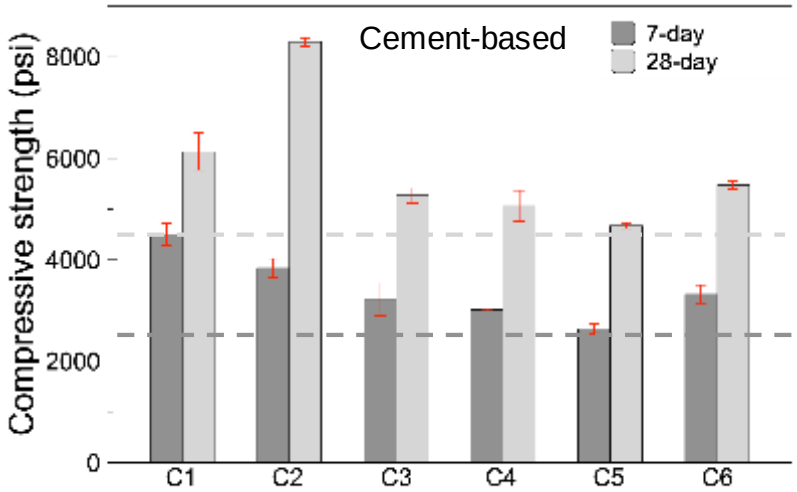
- Regular geopolymer binder
- Binder content: only 14%
  (~25% in regular geopolymer concrete)

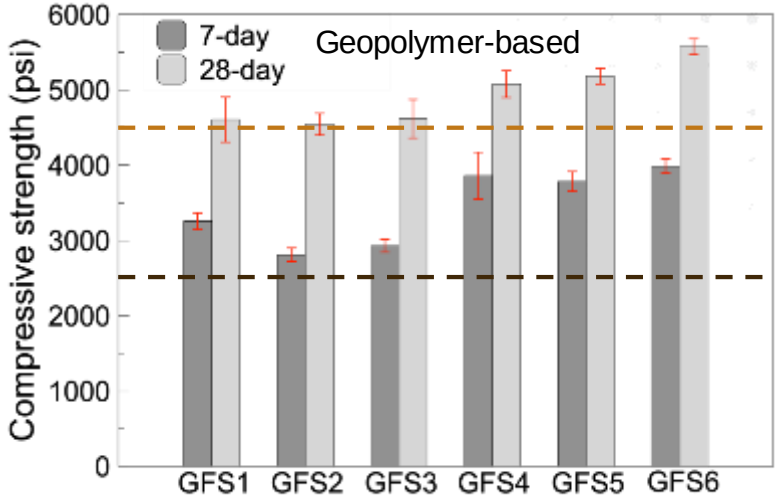


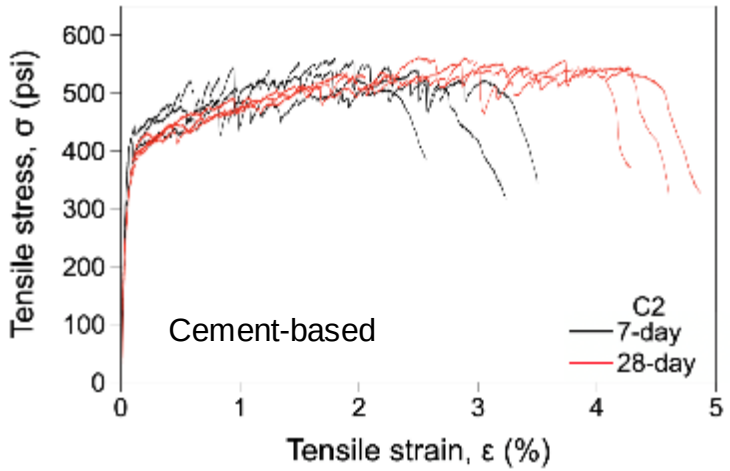


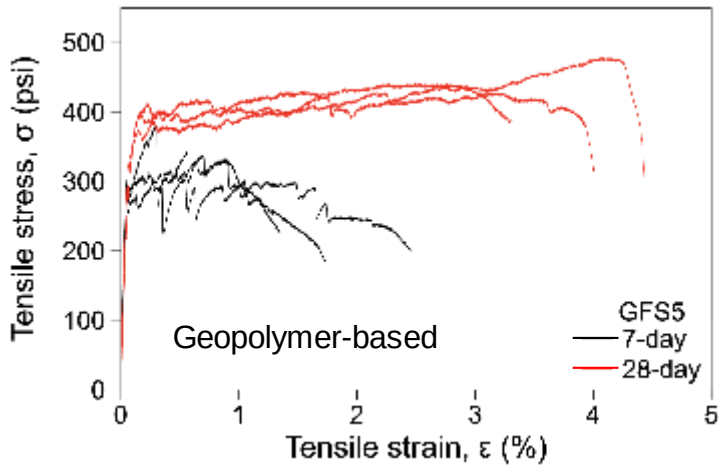
Results (II)

- **Advanced binders**









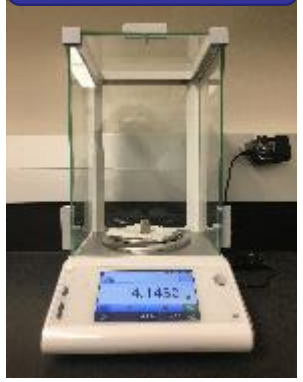
Results (II)

- **Porosity characterization**

1. Sample conditioning

2. Dried sample

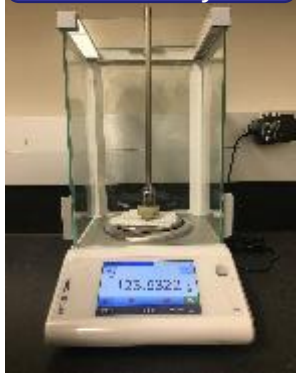
3. Weigh sample



4. Assemble penetrometer

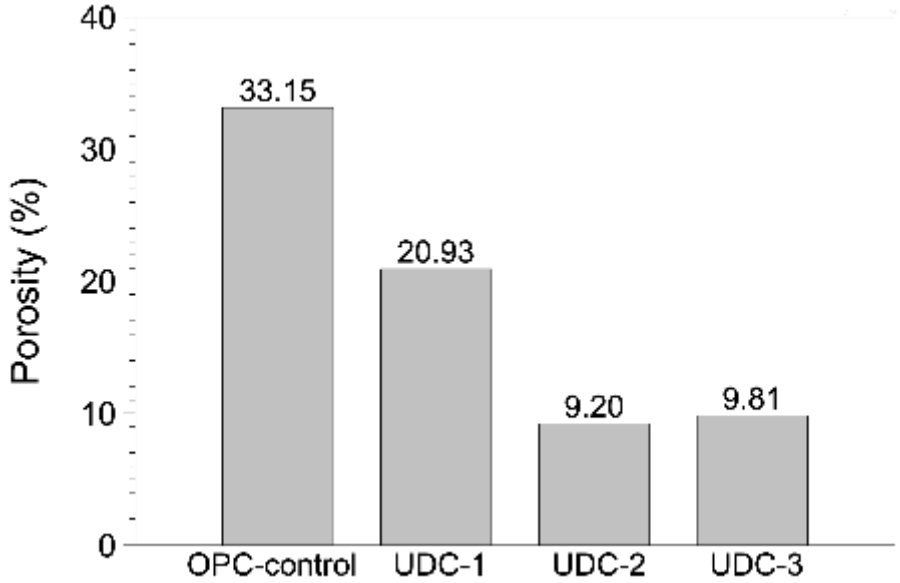
5. Low-pressure analysis

6. Weigh the assembly



7. High-pressure analysis

Mercury Intrusion Porosimetry



Challenges and Risks

- In the past, the high cost limits the wide use of advanced concrete materials
- In our R&D, we aim to develop low-cost, high-performance concrete by
  - Greatly reducing the binder content
  - Simplifying the mixing/processing procedure

  The goal is to keep the total cost below $65/ton

- Main risk: scalability (fiber mixing, compaction)
- Solution: By Q8, we will demonstrate that full-size (500 lb) samples can be produced in a mass production manner, relevant to the precast market

Potential Partnerships

- We are seeking potential industrial and T2M partners
  - Licensing vs. start up

- To other teams: If you have a great binder, we may compact the material to
  - Densify the microstructure and greatly improve the strength/ductility, or
  - Largely reduce the binder content, with the strength unchanged

Summary Slide

- Ultralow-binder-content durable concrete (UDC)
  - Compaction: a very low binder content (10~15%) → low materials cost, green (low carbon emission), less demanding for class F fly ash (if geopolymer binder), highly densified microstructure, high strength, high ductility
  - Microfibers: ultrahigh ductility
- Our team
  - Yu Qiao, UCSD (inventor of the compaction formation technique)
  - Mo Li, UCI (advanced binders)
  - We are seeking industrial/T2M partners
- Project goal
  - Prove the concept (500-lb samples)
  - Prove the cost efficiency (<$65/ton, including labor, equipment, waste)